RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2019 – 2021

Computer Applications in Industrial Drives

ELECTRICAL & ELECTRONICS ENGINEERING

I to IV Semester M. Tech

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

About the Institute:

Ramaiah Institute of Technology (RIT) (formerly known as M. S. Ramaiah Institute of Technology) is a self-financing institution established in Bangalore in the year 1962 by the industrialist and philanthropist, Late Dr. M S Ramaiah. The institute is accredited with "A" grade by NAAC in 2014 and all engineering departments offering bachelor degree programs have been accredited by NBA. RIT is one of the few institutes with prescribed faculty student ratio and achieves excellent academic results. The institute was a participant of the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. All the departments have competent faculty, with 100% of them being postgraduates or doctorates. Some of the distinguished features of RIT are: State of the art laboratories, individual computing facility to all faculty members. All research departments are active with sponsored projects and more than 304 scholars are pursuing PhD. The Centre for Advanced Training and Continuing Education (CATCE), and Entrepreneurship Development Cell (EDC) have been set up on campus. RIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with over 1,35,427 books with subscription to more than 300 International and National Journals. The Digital Library subscribes to several online e-journals like IEEE, JET etc. RIT is a member of DELNET, and AICTE INDEST Consortium. RIT has a modern auditorium, several hi-tech conference halls and all are air-conditioned with video conferencing facilities. It has excellent hostel facilities for boys and girls. RIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association. RIT obtained Academic Autonomy for all its UG and PG programs in the year 2007. As per the National Institutional Ranking Framework, MHRD, Government of India, Ramaiah Institute of Technology has achieved 64th rank in 2019 among the top 100 engineering colleges across India.

About the Department:

The department was started in the year 1962 along with the establishment of the college. In 2003, the Department was recognized as a Research Centre by Visvesvaraya Technological University, Belagavi and offers Ph.D and MSc.(Engg.) by research programs. The Department also started a PG program in Computer Applications in Industrial Drives, in 2004. Our UG programme is accredited **by NBA for five years with effect from July 2015.**

The department has 17 well-qualified faculty members. The entire faculty holds postgraduate degree in either Power Systems / Power Electronics. Six of the faculty members are doctorates. Dr. Premila Manohar is Ph.D in HVDC transmission (from HVE, IISc, 1991), Dr. Pradipkumar Dixit is specialized in High Voltage Engineering (Ph.D from Visvesvaraya Technological University, Belagavi, 2009), Dr.Chandrashekhar Badachi is specialized in High Voltage Engineering (Ph.D from Jain University, Bengaluru, 2016), Dr. Kodeeswara Kumaran G is specialized in Power Electronics for Renewable Energy Applications (Ph.D from NITK, Surathkal, 2018), Dr. S Sridhar is specialized in condition monitoring of Electrical Machines (Ph.D from Visvesvaraya Technological University, Belagavi, 2018) and Dr.Janamejaya C is specialized in Power Electronics & Drives (Ph.D from University of Ontario Institute of Technology, 2018). In addition, Dr. G. R. Nagabhushana, with a long record of service (Retired Professor from HVE, IISc) is with the department as Professor Emeritus.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio- economic needs.

MISSION OF THE INSTITUTE

MSRIT shall meet the global socio-economic needs through

- Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
- Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
- Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs.

QUALITY POLICY

We at MS Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stake holders concerned

VISION OF THE DEPARTMENT

To excel in engineering education and research, inculcating professional ethics in students and emerge as leaders globally in the field of electrical & electronics engineering.

MISSION OF THE DEPARTMENT

The mission of the department is to produce graduates who will

1. Be able to apply their knowledge to identify and solve problems arising in any industry.
2. Be able to contribute to research and developmental activities in frontier areas.
3. Master innovative skills to be entrepreneurs and/or consultants

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

Produce graduates who will

PEO 1: Be knowledgeable to solve complex problems in Industrial drives

PEO 2: Contribute to multidisciplinary scientific research through individual and team work

PEO 3:.Be leaders with managerial skill, demonstrating professional integrity

PROGRAM OUTCOMES (POs):

Students should be able to

PO1: Independently carry out research /investigation and development work to solve practical problems.

PO2: Write and present a substantial technical report/document.

PO3: Demonstrate a degree of mastery over the area of Computer Applications in Industrial Drives.

PO4: Apply the basic knowledge to identify, model and solve electrical drive problems.

PO5: Apply skills to design and develop hardware, software to solve real world problems.

M.Tech: COMPUTER APPLICATIONS IN INDUSTRIAL DRIVES

BREAKDOWN OF CREDITS FOR THE M.Tech DEGREE CURRICULUM

Batch 2019-21

Semester	Core Courses	Electives	Project Work	Seminar/Lab/ Internship	Total
I	8	12	-	4	24
II	8	12	-	4	24
III	4	4	6	6	20
IV	-	-	20	-	20
Total	20	28	26	14	88

I SEMESTER

Sl. No.	Course Code	Course Name	Credits				Total contact hours/ week
			L	T	P	Total/ week	
1	MCID11	Power Electronics	4	0	0	4	4
4	MCID12	DC & AC Drives	4	0	0	4	4
3	MCIDS13	Seminar-I	0	0	2	2	2
4	MCIDExx	Elective - 1	4	0	0	4	4
5	MCIDExx	Elective – 2	4	0	0	4	4
6	MCIDExx	Elective – 3	3	1	0	4	5
7	MCIDL17	Power Electronics Laboratory	0	0	1	1	2
8	MCIDL18	Electric Drives Laboratory	0	0	1	1	2
		Total	**19**	**1**	**4**	**24**	**27**

II SEMESTER

Sl. No.	Course Code	Course Name	Credits				Total contact hours/ week
			L	T	P	Total/ week	
1	MCID21	Advanced Electrical Drives	3	1	0	4	5
2	MCID22	DSP Control of Electric Drives	4	0	0	4	4
3	MCIDS23	Seminar-II	0	0	2	2	2
4	MCIDExx	Elective – 4	4	0	0	4	4
5	MCIDExx	Elective – 5	4	0	0	4	4
6	MCIDExx	Elective - 6	4	0	0	4	4
7	MCIDL27	DSP Controls Laboratory	0	0	1	1	2
8	MCIDL28	Programmable Logic Controllers Laboratory	0	0	1	1	2
		Total	**19**	**1**	**4**	**24**	**27**

III SEMESTER

Sl. No.	Course Code	Course Name	Credits				Total contact hours/ week
			L	T	P	Total/ week	
1	MCID31	Switched Mode Power Supplies	4	0	0	4	4
2	MCIDP32	Project Work Phase-I	0	0	6	6	6
3	MCIDS33	Seminar-III	0	0	2	2	2
4	MCIDI34	Internship	0	0	4	4	4
5	MCIDExx	Elective - 7	4	0	0	4	4
		Total	**8**	**0**	**12**	**20**	**20**

IV SEMESTER

Sl. No.	Course Code	Course Name	Credits				Total contact hours/ week
			L	T	P	Total/ week	
1	MCIDP41	Project Work Phase-II	0	0	20	20	20
		Total	**0**	**0**	**20**	**20**	**20**

***   The student has to earn a total of 28 Credits by choosing courses from the following List of Electives.**

Sl. No.	Course Code	Course Name	Credits			
			L	T	P	Total
1	MCIDE01	Dynamics of Control Systems	3	1	0	**4**
2	MCIDE02	Modeling and Analysis of Electrical Machinery	4	0	0	**4**
3	MCIDE03	Special Machines	4	0	0	**4**
4	MCIDE04	Artificial Neural Networks	4	0	0	**4**
5	MCIDE05	Design of Control Systems	3	1	0	**4**
6	MCIDE06	Electric Vehicle Technology	4	0	0	**4**
7	MCIDE07	ARM Processors	3	0	1	**4**
8	MCIDE08	FPGA and programmable logic	4	0	0	**4**
9	MCIDE09	Electrical Power Quality	4	0	0	**4**
10	MCIDE10	Multilevel Inverters	4	0	0	**4**
11	MCIDE11	Programmable Logic Controllers	4	0	0	**4**
12	MCIDE12	Advanced Mathematics	3	1	0	**4**
13	MCIDE13	Neural and Fuzzy Control of Drives	4	0	0	**4**
14	MCIDE14	Pulse Width Modulation for Power Electronic Converters	4	0	0	**4**
15	MCIDE15	Virtual Instrumentation using LabVIEW	0	2	2	**4**

POWER ELECTRONICS

Subject Code: MCID11 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Sri. Omsekhar Indela /Sri. Tushar Suresh Narasimpur

Course Content:

Unit I

Introduction, classification of power electronic converters and their applications, overview of power Semiconductor switches – Diode, SCR, MOSFET and IGBT, single phase and three phase fully controlled bridge rectifier and effect of source inductance.

Unit II

Buck converter: continuous and discontinuous conduction modes, current and voltage ripple.
Boost converter: continuous and discontinuous conduction modes, current and voltage ripple.
Buck-Boost converter: continuous and discontinuous conduction modes, current and voltage ripple.

Unit III

Non-isolated converters: Cuk and SEPIC converters.
Isolated converters: Flyback, Forward, Push-pull, Half-Bridge and Full-Bridge converters.

Unit IV

Resonant converters: Resonant-switch converter – Zero-current Switching (ZCS) and Zero-voltage Switching (ZVS) converters, Load-resonant converters – series resonant converter, parallel resonant converter and series-parallel resonant converter, Resonant dc link converter.

Unit V

Inverters: Introduction, principle of operation, performance parameters, single phase voltage source inverter, three phase voltage source inverter, voltage control of single phase inverter – single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation, modified sinusoidal pulse width modulation, phase displacement control and space vector modulation.

References

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "*Power Electronics: Converters, Applications and Design*", John Wiley and Sons, 1989.
2. Daniel W. Hart, "*Power Electronics*", McGraw Hill, 2011.
3. M. H. Rashid, "*Power Electronics: Circuits, Devices and Applications*", Third Edition, PHI, 2005.
4. L. Umanand, "*Power Electronics: Essentials and Applications*", Wiley India Pvt. Ltd., 2009.

Course Outcomes (COs):

The student will be able to:

1. Understand the operation of power semiconductor switches and rectifiers. (PO-1, 3)
2. Design basic types of DC-DC converter for power supplies or drives applications. (PO-1, 3, 4)
3. Understand the working of various types of isolated and non-isolated DC-DC converters. (PO-1, 3)
4. Analyze the operation of various types of resonant converters. (PO-1, 3)
5. Analyze the working and voltage control methods of voltage source inverter. (PO-1, 3)

DC & AC DRIVES

Subject Code: MCID12 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Kodeeswara kumaran. G

Course Content:

Unit I

Basic elements of drives, classification of drives, fundamental torque equations, components of load torques, nature and classification of load torques, equivalent values of drive parameters, speed torque conventions, analysis of multi-quadrant operation of various drive systems, modes of operation of electric drives, closed loop control of electric drives.

Unit II

DC motor and their performance, starting, braking, methods of speed control, transfer functions of motors.

Unit III

Rectifier control of DC motors: Controlled rectifier circuits review, braking operation of rectifier controlled motor, single phase full/half controlled rectifier-fed separately excited motor, pulse width modulated rectifiers, multi-quadrant operation of fully controlled rectifier fed DC motors

Unit IV

Chopper Control of DC motors: Chopper circuits review, control techniques, regenerative braking of DC motors, dynamic braking of DC motors, current control, multi-quadrant control of chopper fed motors.

Unit V

Induction motors: Speed-torque characteristics, starting, braking, speed control methods: Scalar control, Vector control (brief). Slip power recovery drives.

References

1. Gopal. K Dubey, "*Power Semiconductor Controlled Drives*", Prentice Hall, 1989.
2. Bimal K. Bose, "*Modern Power Electronics and AC Drives*", Pearson Education, 2002.
3. Andre Veltman, Duco W.J. Pulle and Rik W. De Doncker, "*Fundamentals of Electrical Drives*", Springer, 2016.

Course Outcomes (COs):

The course will enable the student to:

1. Explain the fundamentals of electric drive systems (PO-3,4)
2. Analyze the multiquadrant operation of various drive systems (PO-3,4)
3. Solve problems related to drive systems (PO-3)
4. Analyze the operation of different power converters in drive systems (PO-4,5)
5. Describe the operating principles of an AC drive system (PO-3)

POWER ELECTRONICS LABORATORY

Subject Code: MCIDL17 **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Sri. Omsekhar I / Sri. Tushar Suresh Narasimpur

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List of experiments

1. Static characteristics of SCR, MOSFET and IGBT
2. Simulation of single phase fully controlled bridge rectifier
3. Simulation of three phase fully controlled bridge rectifier
4. Simulation of Buck, Boost and Buck-Boost converter
5. Pulse width modulation controller using 3525 and TL494 ICs
6. Open loop voltage control of Buck converter
7. Open loop voltage control of Boost converter
8. Open loop voltage control of Buck-Boost converter
9. Simulation of Cuk converter
10. Open loop voltage control of Cuk converter
11. Simulation of single phase voltage source inverter
12. Simulation of three phase voltage source inverter

Course Outcomes (COs):

The student will be able to:
1. Demonstrate their ability to use software tools to simulate various types of power electronic converters. (PO-5)
2. Design converters for power supplies. (PO-2,4)
3. Troubleshoot power electronic equipment for faults. (PO-2,5)
4. Understand and apply PWM techniques in converters. (PO-1,2)

ELECTRIC DRIVES LABORATORY

Subject Code: MCIDL18 **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

A) List of Simulation experiments:
1. DC motor control using Class-A chopper controlled dc motor drive
2. DC motor control using Class-D chopper controlled dc motor drive
3. Analysis of dc motor performance with Class-E chopper
4. Analysis of three phase, dual converter fed dc drive capable of operating in all four quadrants
5. Speed control of three phase induction motor using stator voltage control method
6. Speed control of three phase induction motor using stator frequency control method
7. Develop test automation code to simulate class-A chopper fed dc motor
8. Develop test automation code to simulate SPWM inverter fed three phase induction motor

B) List of Hardware Experiments:
9. Speed control of DC motor using IGBT based chopper
10. Speed control of three phase induction motor

(11 to 14) Development of a simple drive system with open loop control

Course Outcomes (CO):

The students will be able to:
1. Model and simulate dc/ac motor drives (PO-3,4,5)
2. Analyze electric drive models (PO-1,3)
3. Develop code (test scripts) to automate the simulation process (PO-1,5)
4. Develop and conduct hardware experiments to study the performance of dc/ac motor drives (PO-1,3,4,5)

ADVANCED ELECTRICAL DRIVES

Subject Code: MCID21 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Smt. Archana Diwakar

Course Content:

Unit I

Dynamic DQ model, Kron's primitive machine, Stanley's equations
Modeling of Induction machine- stator reference frame model, synchronously rotating frame model, arbitrary reference frame model
Scalar control of induction motors, V/f control, speed control with slip regulation, speed control with torque & flux control.

Unit II

Principles of vector control: DC drive analogy, equivalent circuit & phasor diagram, direct vector control, flux vector estimation, indirect vector control, stator flux oriented vector control
Sensorless vector control and flux observers
Direct torque & flux control (DTC), control strategy of Direct Torque Control

Unit III

Modeling of synchronous machine, Permanent magnets and characteristics, PM machines-PM materials, introduction to SPM, IPM, VRM
Control of sinusoidal Surface permanent magnet (SPM) machines-open loop Volts/Hertz control & self-controlled mode, absolute position encoder, vector control, field weakening mode

Unit IV

Synchronous reluctance m/c drives- construction, modes of operation, closed-loop speed control, sinusoidal IPM drives- field weakening control, basics of vector control with stator flux orientation, phasor diagram, BLDC motors- construction, VSI-fed BLDC drive

Unit V

Stepper motors: Types, characteristics, drive circuits for stepper motors- unipolar drive circuit, bipolar drive circuit.
Switched reluctance motors (SRM) : Principle of operation, operating modes, converter circuits.

References

1. Bimal K. Bose, "*Modern Power Electronics and AC Drives"*, Pearson Education, 2002
2. Dr. P. S. Bimbhra, "*Generalized theory of Electrical Machines*", Khanna Publishers, 1983.
3. R. Krishnan, "Electric Motor drives, Modeling, Analysis and Control", Pearson Prentice Hall, 2007
4. S.K.Pillai, "A First Course on Electric Drives", New Age International, 2012.

Course Outcomes (COs):

The course enables the students to:

1. Model electrical machines and to analyse complex systems leading to research and development in the area of electrical drive systems. (PO-1)
2. Analyze scalar and vector control methods for induction motor drives. (PO-3)
3. Analyze control methods for PM drives. (PO-3)
4. Explain the working of synchronous reluctance machine drives. (PO-3)
5. Explain the knowledge gained about the control aspects of stepper motor drive system. (PO-3)

DSP CONTROL OF ELECTRIC DRIVES

Subject code: **MCID22** **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

Course Content:

Unit I

Introduction to the TMS320LF2407 DSP controller, peripherals, C2xx DSP CPU architecture and instruction set (brief), addressing modes, overview of system configuration registers.

Unit II

General Purpose Input/output (GPIO) functionality: Pin multiplexing and general purpose I/O overview, using general purpose I/O ports.
Interrupts: Introduction, hierarchy, interrupt control registers (ICRs), initializing and servicing interrupts.
Analog-to-Digital Converter (ADC): Overview, operation, sequencer configuration of ADCs, sequencer operating modes - start/stop sequencer mode and continuous auto-sequencer mode, triggering sources for ADCs, ADC control registers.

Unit III

Event managers : Overview, event manager interrupts, general purpose timers, compare units, capture units and Quadrature Encoded Pulse(QEP) circuitry, general event manager information.

Unit IV

DSP Based Applications

D**SP based vector control of induction motors**: Overview of three phase induction motor operation, overview of induction motor speed control, overview of speed control system components, Implementation of field oriented control of induction motor – software organization, base value and per-unit model, numerical considerations, numerical format determination, current measurement, speed measurement, speed estimation during high speed region and low speed region, current model, PI regulator, calculation of sine and cosine functions.

Unit V

Overview of Park's and Clarke's transformations, implementing Park's and Clarke's transformations on the LF240X.

DSP based control of stepper motors: Overview of the principles and operation of hybrid stepper motors, overview of a stepper motor drive system, implementation of a stepper motor control system using LF2407 DSP.

DSP based control of permanent magnet brushless motors: Overview of principles of BLDC machines and torque generation, overview of a BLDC control system, implementation of a BLDC control system using LF2407 DSP.

References

1. Hamid Toliyat and Steven Campbell, '*DSP-Based Electromechanical Motion Control*', CRC Press, 2011.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, '*Analysis of Electrical Machinery and Drive Systems*', 2nd Edition, Wiley India, 2010.
3. L.Umanand, '*Power Electronics : Essentials and Applications*', Wiley, 2013.

Course Outcomes (COs):

At the end of the course, the students will be able to

1. describe the architecture of C2xx DSP and explain functions of C2xx assembly instructions (PO- 3)
2. explain the functions of LF2407 peripherals and identify the appropriate the peripherals required for a particular application (PO- 3,5)
3. formulate a control algorithm based on LF2407 for any electric drives applications (PO- 1,5)

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DSP CONTROLS LABORATORY

Subject code: **MCIDL27** **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

LIST OF EXPERIMENTS:

1. Simulation of logic gates and logic functions using sT Embed
2. Evaluation of mathematical expressions using sT Embed
3. Programs to demonstrate 'scope of variables' in sT Embed
4. Simulation of models involving matrices using sT Embed
5. Implementation of F28335 on-board nibble wide LED control
6. Implementation of hex encoder value display using F28335 peripheral explorer kit
7. Measurement of (0-30)V DC voltage using ADC of F28335
8. Measurement of (0-2)A DC current using ADC of F28335
9. Measurement of PWM signal frequency using F28335's CAPTURE unit
10. Generation of a single PWM signal with varying duty cycle using ePWM module (interactive mode and non-interactive mode)
11. Generation of complementary PWM signal with varying duty cycle using ePWM module (interactive mode and non-interactive mode)
12. Switching signal generation for a three phase bridge using ePWM module
13. 9V DC motor control using F28335 (on/off control, Open loop speed control)

Course Outcomes (COs):

At the end of the course, the student will be able to:
1. demonstrate their ability to use software tools to program a DSP for the design needs (PO- 5)
2. decide the use of required DSP peripheral functions for given design requirement (PO- 1,3)
3. write model based programs to control a DSP (PO- 3,5)
4. document the results of hardware/software experiments (PO- 2)

PROGRAMMABLE LOGIC CONTROLLERS LABORATORY

Subject Code: MCIDL28 **Credits: 0:0:1**
Prerequisites: Nil **Contact Hours: 28**
Course Coordinator/s: Sri. Tushar Suresh Narasimpur

LIST OF EXPERIMENTS:

1. Preliminary Programs (Simulation of Gates)
2. Simulation and Emulation of Combinational logic circuits
3. Simulation and Emulation of simple Electrical Ladder Networks
4. Simulation and Emulation of Circuits with special elements (counters, timers etc.,)
5. Simulation and Emulation of I/Os using switch and LED boards using PLC
6. Simulation and Emulation of Traffic Light Control using PLC
7. Simulation and Emulation of Elevator Control using PLC
8. Simulation and Emulation of Batch Process using PLC
9. Simulation and Emulation of Conveyor control using PLC
10. Simulation and Emulation of Process Control problem(s)
11. Implementation of universal motor START/STOP control using PLC (without feedback)
12. Implementation of universal motor START/STOP control using PLC (with feedback)

Course Outcomes (COs):

At the end of the course, the students will be able to:
1. Demonstrate their ability to use software tools to create a PLC program in textual/graphical language, compile and debug it (PO-5)
2. Design and simulate/implement process control solutions using PLCs in the laboratory. (like elevator control, liquid level controller, traffic control, bottling plant control (PO-1,5)
3. Demonstrate team spirit by developing process control solutions as a group in laboratory. (PO-1)

SWITCHED MODE POWER SUPPLIES

Subject Code: MCID31 **Credits: 4: 0: 0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Janamejaya C

Course Content

Unit I

Introduction, Electromagnetics, Magnetic Losses: Hysteresis Losses, Eddy current Losses, Skin Effect, Proximity effect, Design of Inductor, Design of Transformer, Capacitors for Power Electronic Applications, Introduction to Power semiconductor devices – Power diode, MOSFET, IGBT.
Snubber Circuits: Need for Snubber, Turn on Snubber, Turn off Snubber.

Unit II

Introduction to SMPS: Linear Power Supplies, Shunt Controlled Converters, Series Controlled Converters, Overview of Switching Power Supplies, Zener Regulator
DC-DC Switched Mode Converter: Introduction, Buck Converter, Boost Converter, Buck - Boost Converter and Cuk Converter. Selection of power switches, Electrical stress rating, Thermal stress rating, Continuous & Discontinuous Conduction Modes.

Unit III

Isolated converters: Forward converter and forward converter with demagnetizing winding, Flyback converter, Half Bridge Converter and Full Bridge Converter
Switching Techniques: Unipolar and Bipolar.

Unit IV

Resonant Converters: Introduction, Advantages of resonant converters. Resonant Load Converters
Resonant switch converters (Soft Switching): Introduction, ZCS resonant switch converters. ZVS resonant switch converters
Comparison of ZCS & ZVS topologies.

Unit V

Closed loop control: Introduction, Control requirements, Compensator structure, Design of feedback compensators, unity power factor rectifier, resistor emulation principle and applications to rectifiers.

References

1. Switch Mode Power Conversion, Course Notes, CCE, IISc, 2004.
2. Power Electronics-Essentials and applications, L.Umanand, Wiley, 2009.
3. Power Electronics-Converters, Applications, & Design, Ned Mohan, John Wiley & Sons, 2003.

Course Outcomes (COs):

On successful completion of the course, the students will be able to

1. Describe magnetic losses, power diodes, MOSFETs, IGBTs and design reactive circuit elements and snubber circuits. (PO- 1,2)
2. Design various non-isolated DC-DC converters based on different operating modes. (PO- 2,3)
3. Analyze and design switching power converters using isolated DC-DC converters. (PO- 2,3)
4. Design and compare various resonant converters. (PO- 3)
5. Design closed loop control for switching power converters and analyze unity power factor rectifier as well as its resistor emulation. (PO- 3,5)

DYNAMICS OF CONTROL SYSTEMS

Subject Code: MCIDE01 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Dr. Premila Manohar

Course Content:

Unit I

State variable description of linear systems
State space representation of electrical, mechanical and electromechanical systems. Derivation of transfer function from state model. State transition matrix, computation of state transition matrix by series expansion method, Laplace transform approach and Cayley Hamilton theorem. Solution of linear time invariant and time variant state equations.

Unit II

Controllability and Observability
State space representation using canonical forms and phase variables. Transformation to phase variable canonical form, similarity transformations. State variable equations of composite systems, effect of pole zero cancellation, subsystems of composite systems and diagonalisation. Controllability and observability.

Unit III

Design of control system by state space methods
Control system design via pole placement techniques.
Design of state observer - full order observer, effects of addition of the observer on a closed loop system, transfer function of observer based control system.

Unit IV

Linear, discrete, dynamic systems analysis
The z–transform, properties of the z- transform, inverse z-transform, solution of difference equations by z-transform, Impulse sampling and data hold circuits, transfer function of ZOH, transform of functions involving ZOH. Pulse transfer functions. General procedure for obtaining pulse transfer functions.

Unit V

State space analysis of discrete time systems
State space representation of discrete –time systems, controllable canonical form, observable canonical form and diagonal form. Solution of discrete time state space equations, pulse transfer function matrix, Discretisation of continuous time state space equations. Transformations, design via pole placement, controllability and observability, state observer, design of full state observer.

References

1. Katsuhiko Ogata, '*Modern Control Engineering*', PHI, 4th edition, 2002.
2. I. J. Nagrath & M.Gopal, '*Control System Engineering'*, New Age International Publishers, 3rd Edition, 1999.
3. Katsuhiko Ogata, '*Discrete Time Control Systems'*, Pearson education, 2nd edition, 1995.

Course Outcomes (COs):

The student should be able to,

1. Derive and solve state space equations for continuous systems. (PO-2,4,5)
2. Design control systems through pole placement for continuous system. (PO-2,3,4)
3. Derive and solve steady state equations for discrete system. (PO-2,4,5)
4. Design control systems through pole placement for discrete systems. (PO-2,3,4)

MODELING AND ANALYSIS OF ELECTRIC MACHINERY

Subject Code: **MCIDE02** **Credits: 4:0:0**
Prerequisites: **Nil** **Contact Hours: 56**
Course Coordinator/s: Dr.Pradipkumar Dixit

Course Content:

Unit I

Basic Principles for Electric machine analysis: Magnetically coupled circuits-coupled circuits with leakage-linear magnetic system, coupled circuits without leakage-linear magnetic system, non-linear magnetic system, and computer simulation of coupled circuits with and without leakage, winding inductances and voltage equation-synchronous machine, induction machine.

Unit II

Modeling of DC Machines: Theory of operation, induced Emf, equivalent circuit and electromagnetic torque, electromechanical Modeling, State-space modeling, block diagram and transfer functions, field excitation, measurement of motor constants, flow chart for computation.
Phase-controlled DC Motor Drives: Introduction, principles of DC Motor speed control-fundamental relationship, field control, armature control and armature and field controls.

Unit III

Linear Transformations in Machines: The basic two pole machine, Kron's primitive machine, transformer & speed voltages in armature, Invariance of power, transformation from a displaced brush axis, transformation from three phases to two phases, transformation from rotating axes to stationary axes, Physical concepts of Park's transformations, transformed impedance matrix, How to apply generalized theory and electrical torque.

Unit IV

Poly-phase Induction Machines: Introduction, construction and principle of operation, Induction motor equivalent circuit, steady-state performance equations of the induction motor, steady-state performance, Measurement of motor parameters, Dynamic modeling of induction machines.

Unit V

Slot harmonics, skewed slots, effect of space harmonics on IM performance, Reference – Frame Theory**:** Introduction, Background, equations of transformation – change of variables, stationary circuit variables transformed to the arbitrary reference frame, commonly used reference frames, transformation between reference frames.

References

1. Paul C Krause, "*Analysis of Electric Machinery*", McGraw – Hill Book Company, 2002.
2. R. Krishnan, "*Electric Motor Drives – Modeling, Analysis and Control*", PHI Learning Private Limited, New Delhi, 2011.
3. Dr. P. S. Bimbhra, "*Generalized theory of Electrical Machines*", Khanna Publishers, 1983.
4. K. R. Padiyar, "*Power System Dynamics – stability & control*", 2nd Ed, B S Publications, 2002.
5. Fitzerald, Kingsley and Kusko, "*Electric Machinery*", McGraw Hill, KOGA, 1997.

Course Outcomes (COs):

At the end of the course, the students:

1. are able to explain generalized machines theory and linear transformations as applied to electrical machines. (PO- 1)
2. gain in-depth knowledge of energy conversion and to develop models of electromechanical energy conversion devices. (PO-3,4)
3. are able to develop mathematical models of machines using different reference frames and to identify, formulate, and solve problems associated with electrical drives. (PO- 4)
4. are able to use modern engineering and computational tools for analysis and simulation of electrical drive systems. (PO-2,5)

SPECIAL MACHINES

Subject Code: MCIDE03 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Pradipkumar Dixit

Course Content:

Unit I

Single phase Motors: Single phase induction motor- Basic principles, methods of starting, Capacitor Start motor, Shaded Pole motor.
Single phase synchronous motor: Single phase reluctance motor, Hysteresis motor

Unit II

Single phase AC Commutator Machine: Single phase AC commutator, emf produced by pulsating fields, emf produced by rotating fields, commutation in AC machines, 1 phase series motor, phasor diagram, universal motor - generalized theory, repulsion motor - generalized theory

Unit III

Theory of brushless DC machines: 3 phase- 3 pulse brushless DC motor, basic operating principle -operation, voltage and torque equations in machine variables, voltage and torque equations in reference frame variables, analysis of steady state operation

Unit IV

Stepper Motors: Comparison with conventional motor: principle of operation, VR Synchronous Motor- elementary 3- phase 6/2 pole, 4 -phase 8/6 pole VRSM, 3 stack VRSM, PMSM and hybrid SM, circuits of stepping motors, T- displacement circuits, T - pulse rate circuits, T-angle curves for the stepping motor.

Unit V

Schrage Motor: Schematic diagram, arrangement of 3 wedges in stator and rotor slots, circuit characteristics of Schrage motor,

References

1. P.S.Bimbhra,"Generalised Theory of Electrical Machines", Khanna Publishers, 1995.
2. Paul.C.Krause, "Analysis of Electric Machinery", McGraw-Hill, 1987.
3. P.C.Sen, "Principles of Electric Machines and Power Electronics" 2nd edition John Wiley & Sons.
4. Arthur Eugene Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electric Machinery", McGraw-Hill, 2002.

Course Outcomes (COs):

At the end of the course, the students:

1. Would have gained in depth knowledge on comprehensive theory, construction and applications of special purpose machines like stepper motors, single phase induction, synchronous and commutator machines and Schrage motors. (PO-1)
2. Will be able to choose appropriate machines for specific applications. (PO-4)
3. Will be able to use modern tools for analysis and simulation of machines. (PO-5)
4. Can use the concepts for design, construction and application of high performance electric drives. (PO-5)

ARTIFICIAL NEURAL NETWORKS

Subject Code: MCIDE04 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Pradipkumar Dixit / Smt. Kusumika Krori Dutta

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Course Content:

Unit I

Introduction, Fundamental concepts and Models of Artificial Neural systems, Biological Neural Networks, Where Are Neural Nets Being Used, How Are Neural Networks Used, Typical Architectures, Setting the Weights, Common Activation Functions, Mc Culloch –Pitts model- AND gate, OR gate, AND-NOT gate, XOR gate. Application of MATLAB in Neural Networks

Unit II

Simple neural nets for Pattern Classification, Hebb net, examples, Single Layer Perceptron Classifiers, , Single Layer Feedback Networks, examples, Perceptron learning Pattern associations, applications, Training algorithm, Hebb rule &Delta rule, Classification of associative memory. Practical applications of pattern associations in Electrical systems.

Unit III

Hetero associative neural net architecture, examples, Examples with missing and mistake data, Auto associative net architecture, Examples with missing and mistake data, Storage capacity.
Recurrent linear auto associator, Examples.

Unit IV

Discrete Hopfield net, Examples with missing and mistake data, Bidirectional associative net, architecture, Examples with missing and mistake data, Hamming distance, Fixed weight competitive nets, Architecture, applications. Constrained optimization examples.

Unit V

Self-organizing maps, architecture, applications, examples, back propagation neural net, architecture, Application, Example, Applications of neural nets in different fields. Application of neural net in industrial drives. V/f control.

References

1. Laurene Fausett, ‘*Fundamentals of Neural Networks: Architecture, Algorithms and Applications*’, Person Education, 2004.
2. Simon Hayking, ‘*Neural Networks: A Comprehensive Foundation*’,2nd Ed., PHI.
3. S.N Sivanandam, S Sumathi, S.N Deepa ‘ *Introduction to Neural Net using Matlab 6.0’* , TMH, 2008

Course Outcomes (COs):

The course enables the students to:

1. Acquire basic knowledge of logic gates and circuits using Perceptron, Hebbian algorithm and McCulloch -Pitt’s models. (PO-2,3,5)
2. Create models for classification of patterns, identifications of patterns based on perceptron and Hebbian algorithms.(PO-1,3,4,5)
3. Formulate the ANN model to solve problems associated with electrical drives. (PO-1,4,5)
4. Practice ANN model in MATLAB. (PO-4,5)
5. Communicate effectively orally and through writing.(PO-3,5)

DESIGN OF CONTROL SYSTEMS

Subject Code: MCIDE05 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours:70**
Course Coordinator/s: Dr.Premila Manohar

Course Content:

Unit I

Transient and steady state response analysis:
Introduction, transient response of second order systems, design specifications, performance indices, concept of stability, Routh's stability criteria.

Unit II

Control system design by root locus method
Introduction to root locus technique, transfer function of lead, lag, lag-lead, PID and modified PID controllers. Design considerations, design of lead compensator, lag compensator and lag-lead compensator.

Unit III

Control system design by frequency response technique
Introduction to frequency response analysis and Bode plots, design of lead compensator, lag compensator, and lag-lead compensator.

Unit IV

PID controls and discrete control system
Introduction, tuning rules, Zeigler-Nichols rules, Mapping from s-plane to z-plane, Stability of closed loop systems in z-plane -- the Jury's stability test.

Unit V

Design of discrete control systems
Transient and steady state response analysis, Introduction to root locus technique for discrete systems. Design of discrete control systems based on the root locus method. Bilinear transformation, Bode plots and design based on the frequency response method.

References

1. Katsuhiko Ogata, '*Modern Control Engineering*', PHI, 4th edition, 2002.
2. I.J.Nagrath, M.Gopal, 'Control *System Engineering*', New Age International Publishers, 3rd Edition, 1999.
3. Katsuhiko Ogata, '*Discrete Time Control Systems'*, Pearson education, 2nd edition, 1995.

Course Outcomes (COs):

This course enables the students to:

1. Analyze the steady state and transient response of 2^{nd} order system.
   (PO - 3,5)
2. Perform stability analysis for continuous and discrete systems.
   (PO - 3,5)
3. Design control system through root locus technique.
   (PO - 1,3,5)
4. Design control system through Bode plot method.
   (PO - 1,3,5)
5. Design discrete control system through root locus and Bode plot methods.
   (PO - 1,3,5)

ELECTRIC VEHICLE TECHNOLOGY

Subject Code: MCIDE06 **Credits: 4: 0: 0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Janamejaya C

Course content:

Unit I

Brief History of Electric Vehicle. Types of Electric Vehicle in Use Today, Introduction to Hybrid Electric Vehicles (HEV), Series Hybrid and Parallel Hybrid Vehicle fundamentals

Unit II

Battery Technologies: Types of Batteries, Architecture, Battery Charging & Discharging Cycles, Battery Capacity, State of Charge, State of Discharge, Amphour and Energy Efficiency

Unit III

Semiconductor Technology: Fundamentals of Wide-bandgap (WBG) semiconductors, Comparing WBG with Si Devices, Introduction to GaN devices – Band Gap, Critical Field, On-Resistance, Two-Dimensional Electron Gas Model

Unit IV

Chargers: Battery-Charging Infrastructure, EV Charging Levels and Infrastructure, Battery Design and Charging, Introduction to Fuel Cells, Battery Charging, Protection and Management Systems

Unit V

Series Hybrid Electric Drive Train, Design Principles of a Series Hybrid Drive Train, Power Rating Design of the Traction Motor, Power Rating Design of the Engine/Generator. Parallel Hybrid Electric Drive Train Design. Parametric Design of a Drive Train

References

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, John Wiley & Sons Ltd, 2nd ed., 2012.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press Taylor & Francis Group, 2004.
3. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press Taylor & Francis Group, 2003.
4. Ali Emadi, Handbook of Automotive Power Electronics and Motor Drives, CRC Press Taylor & Francis Group, 2005
5. C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, Oxford University Press, 2001.
6. Allen Fuhs, Hybrid Vehicles and the Future of Personal Transportation, CRC Press Taylor & Francis Group, 2009.

Course Outcomes (COs):

The students will be able to:

1. Recognize the evolution of electric vehicles and explain EV and HEV configurations. (PO-4)
2. Understand the working, modeling and analysis of HEV. (PO-3,4)
3. Understand different aspects of Industrial safety and standards. (PO-4)
4. Understand Battery Modelling & Management Systems. (PO-4)
5. Develop architecture of HEV and apply electronic control unit for HEVs.(PO-3,4)
6. Understand different aspects of Electrical machines and power electronic devices used in EV and EHV. (PO-3,4)

ARM PROCESSORS

Subject Code: MCIDE07 **Credits: 3:0:1**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Sri. Vinayaka V Rao

Course Content:

Unit I

ARM embedded systems: The RISC design philosophy, the ARM design philosophy, embedded system hardware, embedded system software. ARM Architecture.

ARM processor fundamentals: Registers, current program status register, pipeline, exceptions, interrupts and vector table, core extensions, Architecture revisions, ARM processor families.

Unit II

Introduction to ARM instruction Set: Data Processing Instructions, branch Instructions, load Store Instructions, software interrupt instruction, program status register instructions, loading constants, ARM v5E extensions, and conditional execution.

Unit III

Introduction to the THUMB Instruction set: Thumb register usage, ARM-Thumb interworking, other branch instructions, data Processing Instructions, single register load –store Instructions, multiple register load store instructions, stack instructions, and software interrupt instruction.
Interrupts & Exception Handling: Exception handling, interrupts, interrupt handling schemes.

Unit IV

LPC 2148- Design of system using GPIO's (LCD interface, 4 x 4 Keypad), Timers, ADC, DAC, UART
Efficient C programming: Overview of C compilers & optimization, Basic C data Types, portability issues, simple programs in c. mixing c & assembler, inline assembler, embedded assembler.
Caches: The memory Hierarchy & cache Memory, cache architecture, Discussions on latest applications of ARM.

Unit V

Introduction to Cortex Mo Processors: Advantages, applications, The Cortex M0 Technical Overview: block diagram, system features, implementation features, debug features.
Overview of the Cortex architecture: registers. Overview of memory, low power features: advantages, sleep modes. Difference between WFE and WFI. Fault handling: causes of faults, lockup: causes, preventions. Differences between ARM7 and cortex M0.

Lab Content:

1. Programs on 8051 Assembly languages such as code conversions, searching.
2. Programs on 8051 Assembly languages such as Fibonacci series, three out of five code.
3. 8051C Programs on Port, Serial communication.
4. 8051 C Programs on interrupts and DAC.
5. ARM Assembly programs on Swapping, Factorial, Hamming code.
6. ARM Assembly programs on transfer of data, Exchange,.
7. ARM Assembly programs on Add, Big endian to little endian.
8. ARM Assembly programs subroutines, ascending order.
9. ARM C programs on serial communication.
10. ARM C program to generate sine wave, triangular wave, saw tooth wave.
11. ARM C program to generate Square wave, Stair case wave.
12. ARM C program to generate PWM wave generation & ADC.

References

1. Andrew N.Sloss, *ARM system Developers Guide*, Elsevier, 2008
2. Joseph Yiu, " The Definitive Guide to the ARM Cortex-M0 ", 1st edition, Newnes - an imprint of Elsevier, 2011
3. William Hohl, *ARM Assembly Language – Fundamentals and Techniques*, CRC Press, 2009
4. J.R.Gibson, *ARM Assembly language An Introduction*, CENGAGE Learning, 2010

Course Outcomes (COs):

The student will be able to:

1. Demonstrate their knowledge of ARM Processors, ARM Cortex, their organization and architecture. (PO-1,3,5)
2. Disseminate their knowledge of assembly and C Language commands. (PO-3,5)
3. Apply the ARM concepts for better understanding of embedded applications. (PO-1,2,4,5)

FPGA AND PROGRAMMABLE LOGIC

Subject code: **MCIDE08** **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

Course Content:

Unit I

Recapitulation of combinational logic circuits. Timing hazards in combinational circuits. Introduction to the history and development of programmable logic. Birth of hardware description languages. Types of programmable logic devices, simple PLDs and CPLDs.

Unit II

Architecture of FPGA - generic features. Definition and construction of FPGA. Architecting an FPGA. Performance, density and capacity of an FPGA. Programmability issues. A study of the XC4000 configurable logic block. Introduction to major FPGA families, Xilinx, Altera and Cypress.

Unit III

Programming of FPGAs. Introduction to VHDL hardware description language. Programming elements, constructs and syntax. Entities and architecture, Creating combinational and synchronous logic. Details of function and procedures. Topics on identifiers, data objects, data types and attributes. Synthesis and fitting of designs.

Unit IV

Simulation and verification of the programs. Considerations of area, speed and device resource utilization in FPGA technology. Creating test benches. Systematic study of implementing state machines using VHDL.

Unit V

FPGA versus CPLD and case studies. Pipe lining and resource sharing concepts. Applications of FPGA in electric drives and communication devices. Future advances in FPGA technology.

References

1. Kevin Skahill, "VHDL for Programmable logic". Pearson Education, 2004
2. John F. Wakerly, 'Digital Design, Principles and Practices', Pearson Prentice Hall.

Course Outcomes (COs):

The students will be able to:

1. Implement an electronic application in a suitable FPGA by using VHDL hardware description language.
   (PO-5)
2. Identify and design state machines using HDL and come up with an integrated chip (IC) solution in the form of a FPGA to be used in the area of drives.
   (PO-4,5)
3. Carry out reverse engineering of a product by using alternative FPGA solutions.
   (PO-1,3,4)

ELECTRICAL POWER QUALITY

Subject code: MCIDE09 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Dr.Pradipkumar Dixit / Sri. Victor George

Course Content:

Unit I

Power Quality Problems: Introduction to electrical power quality, terms and definitions, long and short duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuation, power frequency variations, voltage sags and interruptions.

Unit II

Transient over voltages: Sources of transient over voltages, principles of over voltage protection, devices for over voltage protection, ferroresonance, switching transient problem with loads; nuisance tripping of adjustable speed drives.

Unit III

Fundamentals of harmonics: voltage versus current distortion, displacement and true power factor, triplen harmonics, harmonic indices, harmonic sources from commercial and industrial loads-three phase power converters, DC drives, AC drives, arcing and saturable devices, effects of harmonic distortion, thermal losses, harmonic amplification.

Unit IV

System response to harmonics: system impedance, capacitor impedance, parallel and series resonance, effects of resistance and resistive loads, Mitigation of power system harmonics: introduction, harmonic filters, power converters, capacitor banks, design of series and damped filters.

Unit V

Distributed generation and power quality: operating conflicts, interconnection requirements, power electronics based solutions used in distribution network, custom power compensating controllers, design parameters of D-SVC and D-STATCOM.

References

1. Roger C. Dugan, Mark F, Surya S, H. Wayne, "*Electrical Power Systems Quality*", MGH, 3rd Edition, 2012
2. George J. Wakileh, "*Power Systems Harmonics- Fundamentals, Analysis and Filter Design*", Springer international edition
3. A. Moreno-Mumoz, "*Power Quality- Mitigation Technologies in a Distributed environment*", Springer international edition, 2012

Course Outcomes (COs):

This course enables the students to:

1. Demonstrate their in-depth knowledge about various power quality problems and its effects. (PO - 1)
2. To design harmonic filters tuned to a certain harmonic. (PO - 2, 4)
3. Analyze the design aspects of transient mitigation techniques and voltage quality controllers. (PO - 4)

MULTI-LEVEL INVERTERS

Subject code: **MCIDE10** **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Smt. Mamatha G M/ Sri. Omsekhar Indela

Course Content:

Unit I

Introduction, Conventional two-level inverters for single and three phase applications. Gate drive circuits for devices. Ratings and device stress. Harmonics.

Unit II

Concept of multilevel inverters. Its effect on switch stress and harmonics and EMC. Topologies and waveforms. Effect of multilevel inverters on AC motors. SPWM and SVPWM techniques.

Unit III

Neutral point clamped (NPC) inverters: 3-level, and 5-level, features, advantages and disadvantages. Cascaded H-bridge inverter. Higher levels attained using asymmetrical DC sources, and employing capacitors instead of DC sources. Requirements of number of devices, cost and reliability aspects for different configurations.

Unit IV

Generalized multilevel inverter topology with self-voltage balancing. Multilevel inverters with Flying capacitor topology. Cascading two level inverters. Higher level inverter by using an open end induction machine with multilevel inverters on each side.

Unit V

Issues of capacitor balancing and common mode voltage elimination. 12 and 18 sided Polygonal voltage space vector generation, hybrid inverters and recent trends in multilevel inverters.

References

1. Bin Wu, "*High Power Converters and AC drives*", IEEE press. John Wiley and Sons, Inc. 2006
2. Keith Corzine, "*Operation and Design of Multilevel Inverters*", Developed for the office of Naval Research, Dec 2003, Revised June 2005.
3. J. Rodriguez, J. S. Lai and F. Z. Peng, "*Multilevel Inverters: Survey of Topologies, Controls, and Applications*", IEEE Transactions on Industry Applications, vol. 49, no. 4, Aug. 2002, pp. 724-738.

4. F. Z. Peng, "*A generalized multilevel inverter topology with self-voltage balancing*", *IEEE Trans. Ind. Applications*, vol. 37, pp. 611–618, Mar./Apr. 2001.A. Nabae, I. Takahashi, and H. Akagi, "*A New Neutral-point Clamped PWM inverter*", IEEE Trans. Ind. Applications, vol. IA-17, pp. 518-523, Sept./Oct. 1981.

Course Outcomes (COs):

At the end of the course, the students will :

1. Have an in-depth knowledge of multilevel inverters. (PO-1,3)
2. Design multilevel inverter based drives for induction motors and synchronous motors. (PO-4,5)
3. Design high power converters. (PO-4,5)

PROGRAMMABLE LOGIC CONTROLLERS

Subject Code: MCIDE11 **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Sri. Tushar Suresh Narasimpur

Course Content:

Unit I

Introduction to PLC: History, principles of operation, types of PLCs, PLC vs other types of control, advantages of PLCs.
Digital Logic, Number systems & Binary Codes: Review.

Unit II

PLC Architecture: General block diagram, processors, power supply, memory systems, analog I/O systems, discrete I/O systems, special function I/O modules, brief overview of architecture of different PLC manufacturers.

Unit III

PLC Programming:
Programming Methods: Ladder diagrams (detailed coverage), functional blocks, sequential functional charts, instruction list, structured text.
PLC functions: Data transfer, data manipulation, program control, arithmetic, special functions.

Unit IV

IEC 1131 standard, programming languages, software systems (brief coverage)
Design aspects: Flow charts, pseudo code, PLC system and safety, emergency stop, commissioning process, documentation process (brief coverage)
Simple programs: ON/OFF control, one shot, toggle action, latch up, code conversion, alarm annunciator etc.

Unit V

Case studies and creation of ladder diagram from process control descriptions. PLC Applications.

References

1. L.A.Bryan, E.A.Bryan, "*Programmable Controllers: Theory & Implementation*", Industrial Text Company Publications, 2nd Edition, 1997
2. John R Hackworth & Frederick D.Hackworth Jr, "*Programmable Logic Controllers: Programming methods and applications*", Pearson education, 2008
3. W.Bolton, "*Programmable Logic Controllers*", Elsevier, 4th Edition, 2006
4. E.A.Parr, "*Programmable Controllers : An Engineers Guide*", Newness, 3rd Edition, 2003

Course Outcomes (COs):

The course will enable the student to:

1. Demonstrate their in-depth knowledge about the operation of programmable logic controllers and its components. (PO-5)
2. Write a PLC program using ladder diagram for Boolean functions and process control functions. (PO-5)
3. Design and implement process control solutions using PLCs. (like elevator control, liquid level controller, traffic control, bottling plant control) (PO-5)
4. Demonstrate knowledge about IEEE standards, Programming languages and software systems. (PO-5)
5. Demonstrate their ability to develop end to end design of specific applications of PLC with relevant documentation (PO-5)

ADVANCED MATHEMATICS

Subject Code: MCIDE12 **Credits: 3:1:0**
Prerequisites: Nil **Contact Hours: 70**
Course Coordinator/s: Dr. Sureshbabu R

Course Content:

Unit I

Linear Algebra I: Introduction to linear systems, matrix notation, Rank and Consistency, geometry of linear equations, Gaussian elimination, Gauss-Jordan elimination. Eigen values and Eigen vectors, diagonalization, power of a matrix and solution of ODE.

Unit II

Linear Algebra II: Symmetric Matrices, properties, Orthogonal diagonalization, Quadratic forms, Canonical form and Nature of Quadratic forms and SVD.
Vector Spaces: Vector spaces and subspaces, linear independence, basis and dimension, Coordinate system, Kernel and Range of linear transformation.

Unit III

Linear Algebra III: Orthogonal sets, orthogonal projections, Gram – Schmidt process, Least square problems.

Unit IV

Applications of Laplace Transforms: Laplace transforms of elementary functions, Linearity and first shifting theorem, Properties of L.T. (without proofs), transforms of derivatives and integrals, inverse Laplace transforms, L.T. solution of initial value problems and simultaneous equations, solution of wave and heat equation using Laplace transform.

Unit V

Applications of Fourier series: Euler's formula, Fourier coefficients, Even and odd functions, Fourier series of rectangular wave, square wave, saw tooth wave, rectangular pulse, half wave rectifier, Fourier half range cosine and sine series, frequency spectrum of a function, Fourier series solution of wave and heat equation.

References

1. Erwin Kreyszig, "*Advanced Engineering Mathematics*", 10th edition, Wiley, 2015
2. David C. Lay, "*Linear Algebra and its Applications*", 3rd Edition, Pearson Education, 2003
1. Peter V. O'Neil, "*Advanced Engineering Mathematics*", 7th edition, Thomson learning, 2008
2. Strang. G, "*Linear Algebra and its Applications*", 3rd Edition, Thomson Learning, 1988

Course Outcomes (COs):

At the end of the course, the student will be able to:

1. Solve system of linear equations and system of simultaneous ODE. (PO-3)
2. Express the given form to canonical form and determine different characteristics of linear transformation. (PO-3)
3. Find orthonormal vectors using Gram-Schmidt process and solve problems using least square concepts. (PO-3)
4. Apply Laplace transforms to find the solutions of initial value problems, simultaneous equations and partial differential equations. (PO-3)
5. Formulate Fourier series for various wave forms and solve partial differential equations using Fourier series. (PO-3)

NEURAL AND FUZZY CONTROL OF DRIVES

Subject code: **MCIDE13** **Credits: 4:0:0**
Prerequisites: Knowledge of Electric Drives **Contact Hours: 56**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

Course Content:

Unit I

AC Drive Systems: Review
Structure of AC drive system, Induction motor equivalent circuit, scalar control and vector control, pulse width modulation, space vector in electrical systems, induction motor control strategies
Control systems for ac drives: Review
Control systems-Classification, characteristics of control systems, Objects of control system, basic principle of microcomputer control

Unit II

Elements of neural control
Neuron type, ANN architecture
Training algorithms - error back propagation algorithm, algorithms derived from back propagation method, training algorithms for neurons with step activation functions, Voronoi diagram algorithm
Control applications of ANN

Unit III

Neural FPGA implementation
Neural Network Implementation - Analog implementation, digital implementation, Hybrid implementation and optical implementation.
Neural network design and implementation strategy-General implementation principles, Model digitization, Digital model implementation using logic gates, Hardware implementation complexity analysis (through case studies).

Unit IV

Fuzzy logic fundamentals
Fuzzy sets and fuzzy logic, types of membership functions, linguistic operators, fuzzy logic operators, fuzzy control systems, fuzzy logic in power and control applications,

Unit V

Neural current and speed control of induction motors
Current control algorithm-switching strategy, adopted neural algorithm, condition for accurate current control, current control implementation methods, induction motors controller design, the reference speed calculator and sine wave generator, multiplication and algebraic calculation, PWM generation, implementation of speed control strategy

References

1. M.N.Cirstea, A.Dinu, J. G.Khor, M.McCormick, "*Neural and Fuzzy Logic Control of Drives and Power Systems*", Newness publications, 2002.
2. Laurene V. Fausett, "*Fundamentals of Neural Networks: Architectures*", Algorithms and Applications, Pearson Education India, 2006.
3. George J. Klir, Bo Yuan, "*Fuzzy Sets and Fuzzy Logic: Theory and Applications*", Prentice-Hall of India Pvt. Ltd., 2002.

Course Outcomes (COs):

The course will enable the student to:
1. Describe the function of each component in an electric drive system. (PO - 3,4)
2. Explain the fundamentals of artificial neural networks and the different training algorithms. (PO - 3)
3. Describe the design process and strategies involved in neural network implementation. (PO - 3)
4. Explain the fundamentals of fuzzy logic control. (PO - 3)
5. Apply concepts of neural networks to control an induction motor. (PO - 3,4)

PULSE WIDTH MODULATION FOR POWER ELECTRONIC CONVERTERS

Subject code: **MCIDE14** **Credits: 4:0:0**
Prerequisites: Nil **Contact Hours: 56**
Course Coordinator/s: Sri. Omsekhar Indela

Course Content:

Unit I

Power electronic converters: Overview of dc-dc buck and boost converters, H-bridge, multilevel converters – diode clamp, flying capacitor and cascaded-cell converters; voltage source and current source converters; evolution of topologies for dc-ac power conversion from dc-dc converters.
Applications of voltage source converters: Overview of applications of voltage source converter, motor drives, active front-end converters, reactive compensators, active power filters.

Unit II

Purpose of pulse-width modulation: Review of Fourier series, fundamental and harmonic voltages; machine model for harmonic voltages; undesirable effects of harmonic voltages – line current distortion, increased losses, pulsating torque in motor drives; control of fundamental voltage; mitigation of harmonics and their adverse effects.
Pulse-width modulation (PWM) at low switching frequency: Square wave operation of voltage source inverter, PWM with a few switching angles per quarter cycle, equal voltage contours, selective harmonic elimination, THD optimized PWM, off-line PWM.

Unit III

Sine-Triangle-comparison based PWM: Average pole voltages, sinusoidal modulation, third harmonic injection, continuous PWM, bus-clamping or discontinuous PWM.
Space vector based PWM: Space vector concept and transformation, per-phase methods from a space vector perspective, space vector based modulation, conventional space vector PWM, bus-clamping PWM, advanced PWM, triangle-comparison approach versus space vector approach to PWM.

Unit IV

Analysis of line current ripple: Synchronously revolving reference frame; error between reference voltage and applied voltage, integral of voltage error; evaluation of line current ripple; hybrid PWM for reduced line current ripple.

Analysis of dc link current: Relation between line-side currents and dc link current; dc link current and inverter state; rms dc current ripple over a carrier cycle; rms current rating of dc capacitors.

Analysis of torque ripple: Evaluation of harmonic torques and rms torque ripple, hybrid PWM for reduced torque ripple.

Unit V

Inverter loss: Simplifying assumptions in evaluation of inverter loss, dependence of inverter loss on line power factor, influence of PWM techniques on switching loss, design of PWM for low inverter loss.

Effect of inverter dead-time effect: Requirement of dead-time, effect of dead-time on line voltages, dependence on power factor and modulation method, compensation of dead-time effect.

Over-modulation: Per-phase and space vector approaches to over-modulation, average voltages in a synchronously revolving d-q reference frame, low-frequency harmonic distortion.

PWM for multilevel inverter: Extensions of sine-triangle PWM to multilevel inverters, voltage space vectors, space vector based PWM, analysis of line current ripple and torque ripple, trade-off between switching losses and THD.

References

1. D. Grahame Holmes and Thomas A. Lipo, "*Pulse Width Modulation for Power Converters: Principles and Practice*", John Wiley and Sons, 2003.
2. Ned Mohan, Tore M. Undeland, William P. Robbins, "*Power Electronics: Converters, Applications and Design*", John Wiley and Sons, 1989.
3. M. H. Rashid, "*Power Electronics: Circuits, Devices and Applications*", Third Edition, PHI, 2005.

Course Outcomes (COs):

The student will be able to:

1. Acquire basic knowledge of power electronic converters. (PO-3)
2. Understand purpose of pulse width modulation for power electronic converters. (PO-3, 4)
3. Explain various pulse width modulation techniques adopted for power converters. (PO-3, 4)
4. Analyze line current ripple and torque ripple for power converters. (PO-4, 5)
5. Apply pulse width modulation for multilevel converter. (PO-4, 5)

VIRTUAL INSTRUMENTATION USING LABVIEW

Subject Code: MCIDE15 **Credits: 0: 2: 2**
Prerequisites: Nil **Contact Hours: 84**
Course Coordinator/s: Dr. Kodeeswara Kumaran G

TUTORIAL TOPICS

LabVIEW introduction, Navigating LabVIEW, VIs and Functions, Dataflow, LabVIEW data types, Tools for programming, cleaning, and organizing VIs, Building a basic VI, Correction of broken VIs, Debugging techniques, Error handling, Loops review, While loops, For loops, Timing a VI.

Data feedback in loops, Plotting data waveform chart, Arrays, Common array functions, Polymorphism, Auto-indexing, Clusters, Type definitions, Case structures.

Event driven programming, Understanding modularity, Icon, Connector Pane, Documentation, Using SubVIs, Measuring fundamentals with NI DAQ hardware, Accessing files form LabVIEW, High-level and low level file I/O functions, Comparing file formats, Using sequential programming, Using state programming, State machines.

Variables, Using variables appropriately, Race conditions, Communicating data between parallel loops, Implementing simple design patterns and multiple loop design patterns, Functional global variable design pattern, Error handlers, generating error codes and messages, Timing design pattern, VI server architecture, Property nodes.

Controlling user interfaces, File formats, Creating a file and folder paths, Write and read binary files, Working with multichannel text files with headers, Access TDMS files in LabVIEW and Excel, Refactoring codes, Creating and distributing applications.

LIST OF EXPERIMENTS

1. (i) Getting familiar with LabVIEW environment
   (ii) Demonstration of document codes
2. (i) Programs to perform arithmetic operations
   (ii) Programs to understand dataflow
3. (i) Programs using *while* loops and *for* loops
   (ii) Programs to demonstrate data tunnels in loops
4. (i) Program to plot data waveforms
5. (ii) Program using n-dimensional arrays
6. (i) Programs using shift registers
   (ii) Programs using case structures
7. Programs to read data from and write data to a binary/ASCII/LVM file

8. (i) Programs to implement state machines
   (ii) Programs to execute sequential tasks
9. Program to acquire data and control processes with myDAQ/myRIO hardware devices
10. Implementation of voltmeter, ammeter and wattmeter functions using myDAQ/myRIO
11. Implementation of DC motor control using myRIO

(12 to 14) Capstone project

References

1. LabVIEW fundamentals by National Instruments
2. LabVIEW Basics-I course manual by National Instruments
3. LabVIEW Basics-II course manual by National Instruments

Course Outcomes (COs):

At the end of the course, the student will be able to:

1. Develop VI program in LabVIEW to meet given design requirements. (PO-5)
2. Debug and deploy LabVIEW programs on host computer/ myRIO. (PO-5)
3. Deploy myDAQ for signal acquisition and processing. (PO-5)
4. Develop a standalone system using myRIO for simple process control requirement. (PO-4,5)